712CD

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Name of Principal Author and all other author(s):

Christopher M. Wilcox

Principal Author's Organization and address:	Phone: (410) 306-0475
US Army Evaluation Center 4120 Sysquehanna Ave. APG, MD 21005	Fax: (410) 306-0398
	Email: chris.wilcox@atec.army.mil

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The Four-Element Framework: An Integrated Test and Evaluation Strategy

Our Army . . .Our Soldiers . . .Our Equipment

Christopher Wilcox

Army Evaluation Center
Aviation Evaluation Directorate
Aberdeen Proving Ground, MD
14 June 2007

Agenda

- Background
- Introduction
- Overview
- Element/Interface Development
- Application
- Strengths
- Concept Development & CH-47F Case Study
- Summary

Background

DoD 5000.1

DOD 5000.1 – "The primary objective of Defense acquisition is to acquire quality products that **satisfy user needs with measurable improvements to mission capability**…"

JCIDS

Joint Capabilities Integration and Development System

- War Fighting Capability Gaps
- Material/Non-material Solutions

Materiel System
Performance Attributes
Key Performance Parameters

Capabilities Development Document

Capabilities Production Document

DoD Architecture Framework Products

OV – Operational View – mission tasks, activities, operational elements and information required to accomplish warfighting mission.

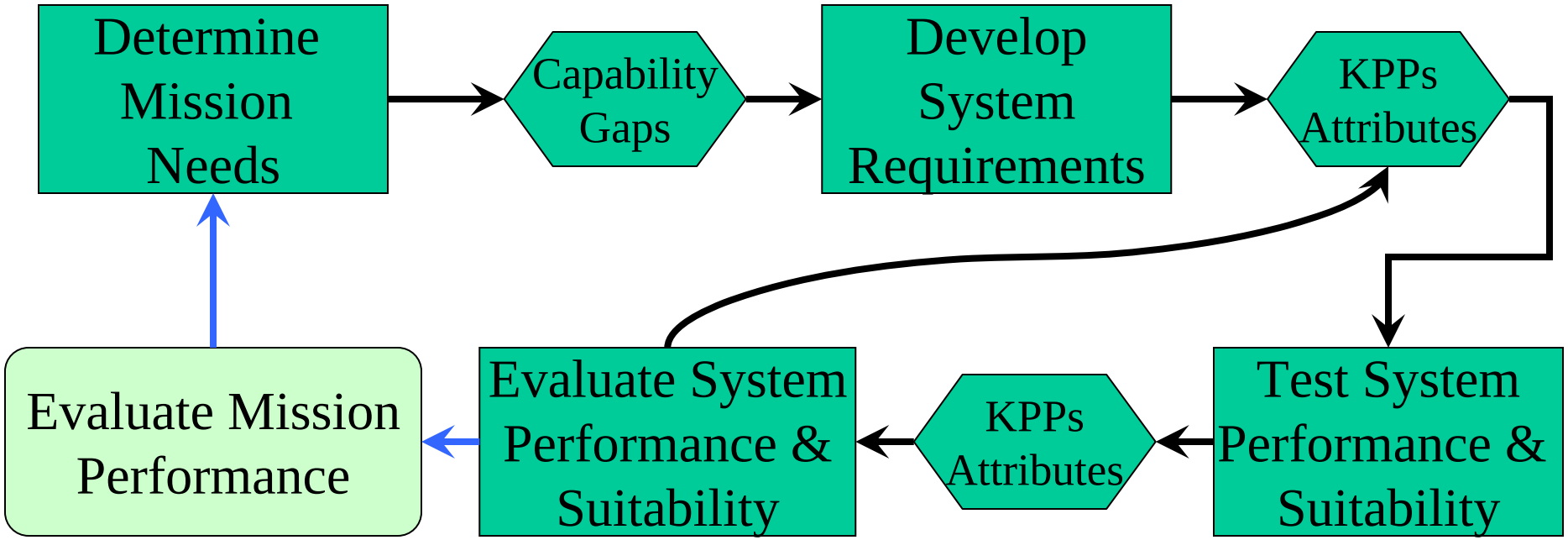
SV – System View – system elements and capabilities necessary to support warfighting functions.

TV – Technical View – set of rules and standards to ensure that a system satisfies a set of operational requirements.

AV – All View – overarching architecture that supports the OV, SV and TV.

Introduction

T&E Process Paradigms: Traditional; Proposed



Completes the Feedback Loop to Mission Needs

Overview

The Four Elements

Mission Perspective

T&E Perspective

Purpose (What)

Means (How)

MISSION ELEMENT
Mission Tasks and Sub-tasks

SYSTEM ELEMENT
System and Sub-system Functions

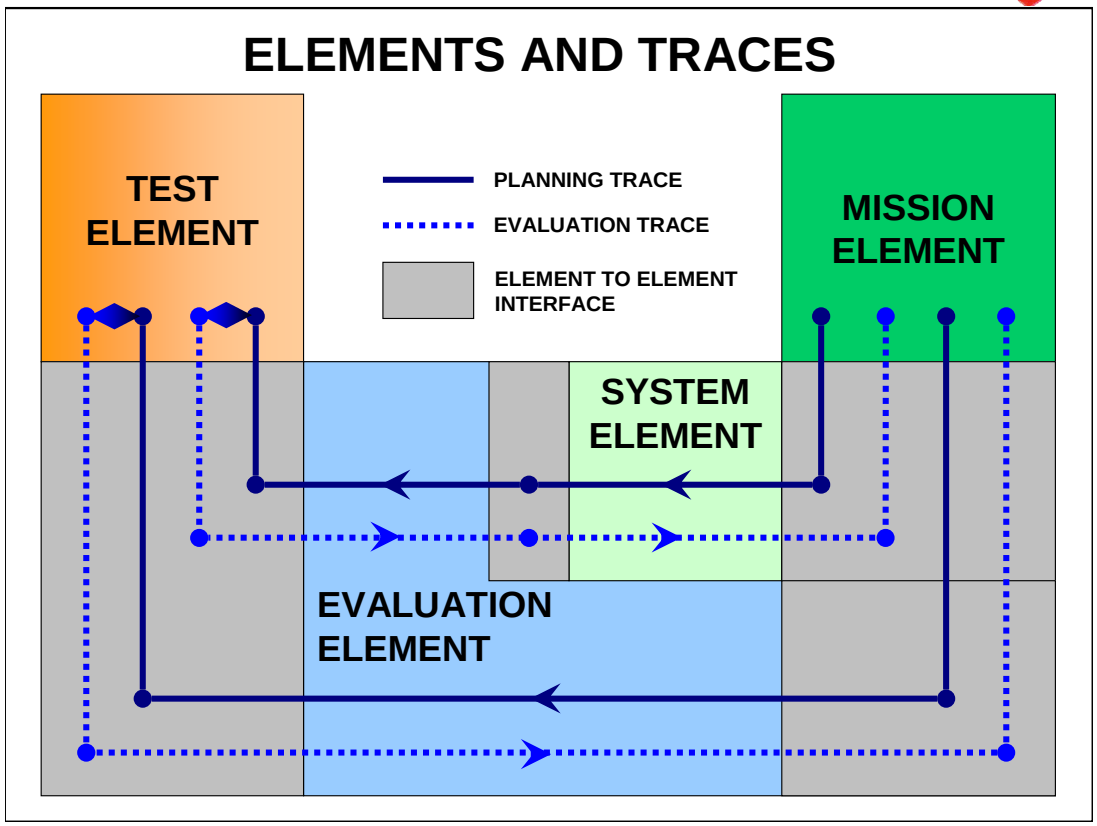
EVALUATION ELEMENT
Mission Ability and System Capability Measures

TEST ELEMENT
Data Products and Data Sources

Purpose (What)

Means (How)

Overview
Elements, Interfaces and Traces



Elements

- Mission, System, Evaluation, and Test

Interfaces

- Mission to System
- Mission to Evaluation
- System to Evaluation
- Evaluation to Test

Traces

Planning = Mission to Test

Evaluation = Test to Mission

Two Types:

- Type 1 links Mission, System, Evaluation and Test Elements.
  - Plans and evaluates mission task ability through system function capability.
- Type 2 links Mission, Evaluation and Test Elements.
  - Plans and evaluates mission task ability directly.

Element/Interface Development Mission Element

Purpose

- To describe unit mission and tasks.

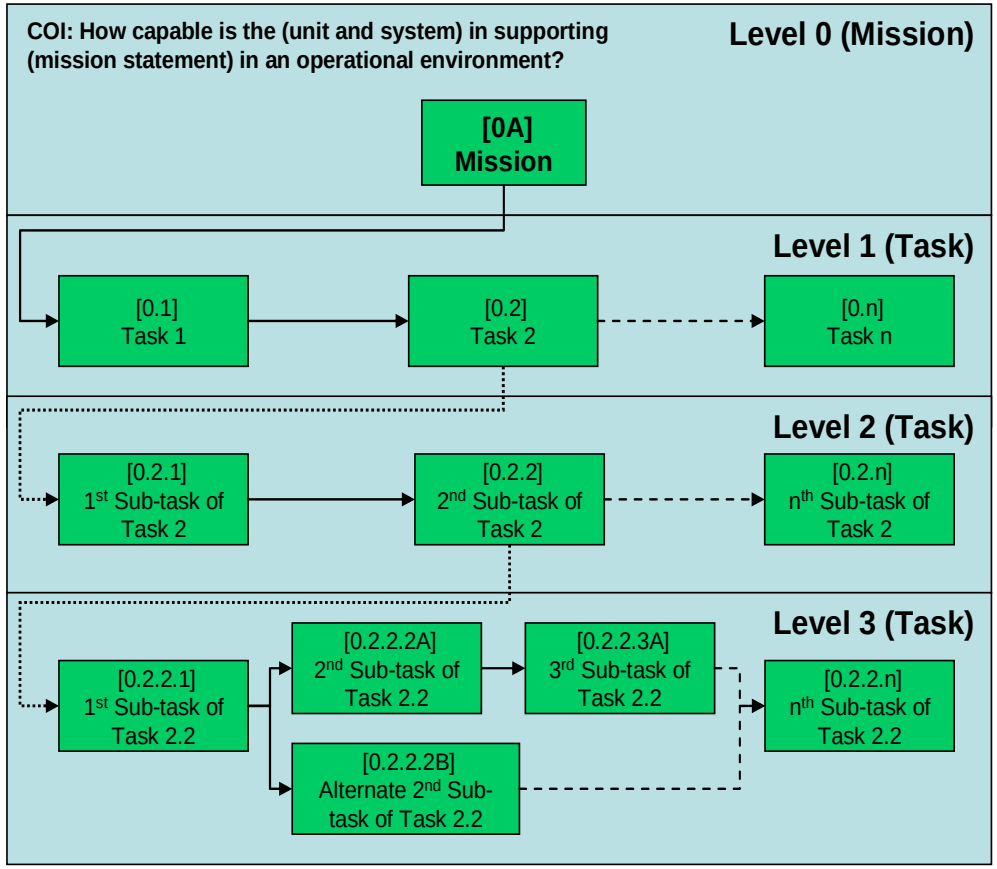
-- A task is defined as a discrete action that the unit (system and its operators) must perform in order to accomplish its mission.

Components

- Critical Operational Objective: Mission based – "How capable is the (unit and system) in supporting (mission statement) in an operational environment."

- Task Levels: Orderly breakdown of the mission into tasks and sub-tasks.

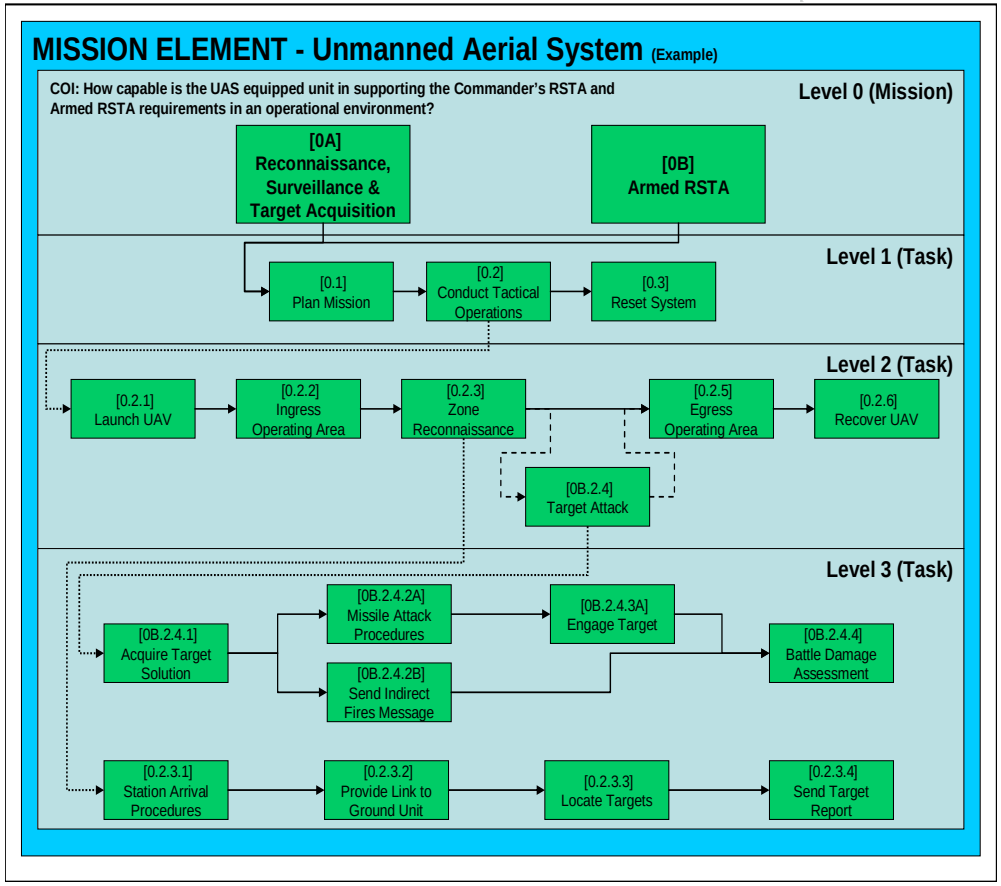
- Alternate Mission Tasks: Optional mission tasks used to accomplish part(s) of the mission. Alternate task options define different "mission threads."



Element/Interface Development Mission Element – Example

Development Keys

- Temporal Format.
  - Temporal format provides a block diagram of mission to mission tasks in order of their occurrence.
  - Supports development of mission threads.
- Lowest Level of Mission Tasks.
  - Lowest level mission tasks must be measurable.
  - Evaluated directly or indirectly via evaluation of system function capability.
- Support Documents.
  - Mission Need Statement, Initial Capabilities Document, Operational and Organizational Plan, Universal Task Lists, Capabilities Development/Production Documents (CDD/CPD).
  - Integrated architecture products in CDD/CPD uniquely support mission element.
    - OV-1: Who, How, Where, When, Why of the system and its mission.
    - OV-5: Operational activities (mission tasks).
    - OV-6c: Association of capabilities with sequences of operational activities (mission tasks).



Element/Interface Development
System Element

Purpose

- To describe the system and the system functions and characteristics.

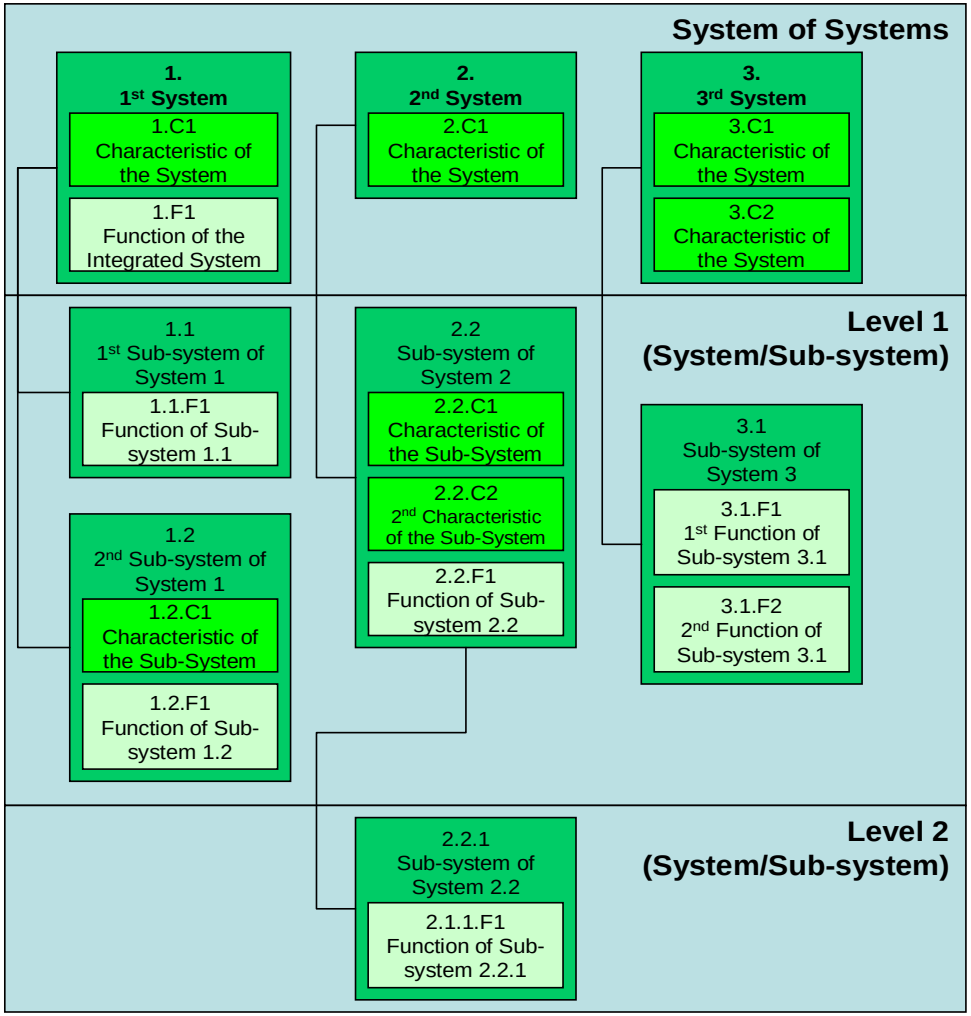
Components

- System Items: Makeup of the system and sub-systems.

- System Functions: Description of the function an item must perform in support of the mission.

- System Characteristics: Description of a particular quality of the system that effects whether the item can perform a function.

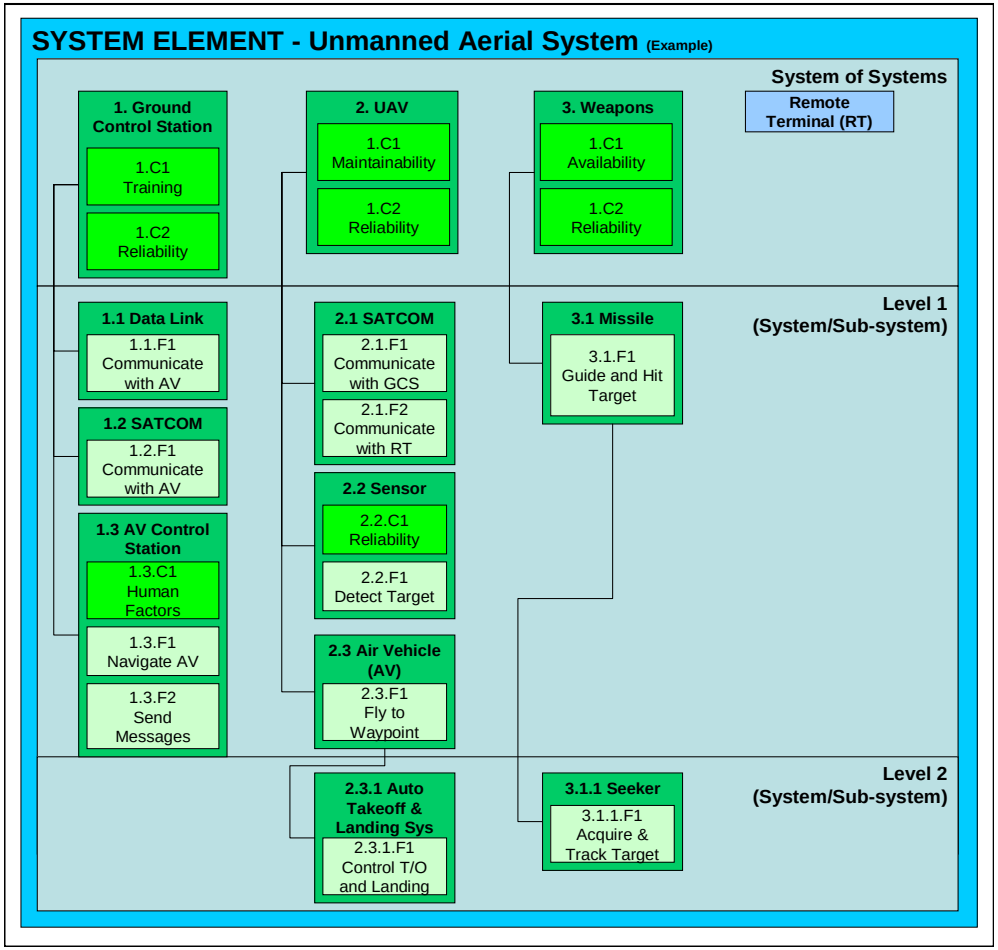
- System Level: Level of systems, sub-system, and components from the system-of-systems perspective.



Element/Interface Development System Element – Example

Development Keys

- Item to Function Link.
  - Objective is to define the system functions.
  - System item is the sub-system responsible for providing the function.
- System-of-Systems.
  - Include systems that are not part of the system being developed and evaluated if they are required to support the mission.
- Lowest Level of System Function.
  - Should be associated with the accomplishment of a mission task.
  - Measurable by T&E.
- Risk Areas
  - Items and functions can be based on a specific area of developmental risk.
- Support Documents.
  - System Work Breakdown Structure
  - Integrated architecture products in CDD/CPD uniquely support mission element.
    - SV-1: Systems required to support the mission and the interfaces between them.
    - SV-4: System functions required to support the operational activities (mission tasks).



Element/Interface Development
Mission to System Interface

Purpose

- To describe how the mission tasks relate to the system functions.

Components

- Mission Tasks: Taken from the mission element.

- System Functions and Characteristics: Taken from the system element.

- Input Rule: Description of how the system items relate to the mission task. Uses logical input rules, such as AND and OR to describe links to more than one system or function.

	[0.1] Task 1	[0.2.1] 1st Sub-task of Task 2	[0.2.2.1] 1st Sub-task of Task 2.2	[0.n] Task n
System 1				
1.C1 Characteristic of System 1	Input Rule (AND/OR)	Input Rule (AND/OR)	Input Rule (AND/OR)	
1.1.F1 Function of Sub-system 1.1	Input Rule (AND/OR) / Conditions		Input Rule (AND/OR) / Conditions	
1.2.F1 Function of Sub-system 1.2		Input Rule (AND/OR) / Conditions		
System 2				
2.2.C1 Characteristic of Sub-system 2.2		Input Rule (AND/OR)	Input Rule (AND/OR)	
2.2.F1 Function of Sub-system 2.2		Input Rule (AND/OR) / Conditions		
2.2.F1 Function of Sub-system 2.2			Input Rule (AND/OR) / Conditions	
System 3				
3.C1 Characteristic of System 3				Input Rule (AND/OR)
3.1.F1 1st Function of Sub-system 3.1				Input Rule (AND/OR) / Conditions

- Conditions: Description of the physical, military, and civil variations that effect performance of a task. For example; weather conditions, countermeasures, urban environment, etc.

Element/Interface Development Mission to System – Example

Development Keys

- Input Rule.
  - Link every function required to support the mission task.
  - Link alternate system functions that support the mission task.
  - Top row for every system defines if the system supports the mission task with a function. (Used later to link system suitability to the task.)
  - Linkages are important since they will be used to evaluate mission tasks based on the evaluation of system functions/suitability.
- Conditions.
  - Consider the conditions based on the ability to support the mission task, but…
  - The specific function may drive the choice of applicable conditions. For example; terrain may effect the communication functions of line-of-sight systems but not effect satellite systems.
- Support Documents.
  - Initial Capabilities Document and System Threat Assessment Report to determine conditions.
  - Factors of METT-TC to determine conditions.
  - Integrated architecture products in CDD/CPD uniquely support mission element.
    - SV-5: Maps operational activities (mission tasks) from the OV-5 to the system functions from the SV-4.

MISSION TO SYSTEM LINKS - Unmanned Aerial System (Example)

KEY: MISSION TASK / LINKS / CONDITIONS	SYSTEM and SYSTEM FUNCTION	0.2 Conduct Tactical Operations	0.2.1 Launch UAV	0.2.2 Ingress OA	0.2.5 Egress OA	0.2.6 Recover UAV	0B.2.4.3A Engage Target
1.0 Ground Control Station	1.C1 Training	All Functions	All Functions	All Functions	All Func.	All Func.	All Functions
	1.1 Data Link — 1.1.F1 Communicate with AV	OR 1.2.F1 1. Terrain 2. AV Altitude 3. EW Jamming	OR 1.2.F1 AND 2.3.1.F1 0.2	OR 1.2.F1 AND 1.3.F1, 2.3.F1 0.2	0.2.2 0.2	0.2.1 0.2	OR 1.2.F1 AND 3.1.F1 0.2
	1.2 SATCOM — 1.2.F1 Communicate with AV	OR 1.1.F1 1. EW Jamming	OR 1.1.F1 AND 2.3.1.F1 0.2	OR 1.1.F1 AND 1.3.F1, 2.3.F1 0.2	0.2.2 0.2	0.2.1 0.2	OR 1.1.F1 AND 3.1.F1 0.2
	1.3.C1 HFE	All Functions	All Functions	All Functions	All Func.	All Func.	All Functions
	1.3 AV Control Station — 1.3.F1 Navigate AV			AND 2.3, (1.1 OR 1.2) 1. Flight Profile 2. Weather (Icing) 3. EW Jamming 4. Terrain	0.2.2 0.2.2		
2.0 UAV	2.C1 Reliability		All Functions	All Functions	All Func.	All Func.	
	2.3 Air Vehicle — 2.3.F1 Fly to Waypoint			AND 1.3, (1.1 OR 1.2) 1. Winds 2. Flight Profile 3. Day/Night 4. Weather (Icing)	0.2.2 0.2.2		
	2.3.1 ATLS — 2.3.1.F1 Control Takeoff and Landing		AND (1.1 OR 1.2) 1. Winds 2. Runway Length 3. Density Altitude			0.2.1 0.2.1	
3.0 Weapon	3.C1 Reliability				.	.	All Functions
	3.1 Missile — 3.1.F1 Guide and Hit Target						AND(1.1OR1.2) 1. Target Type 2. Weather 3. Slant Range

Element/Interface Development Evaluation Element

<u>Purpose</u>

- To describe the evaluation measures and how they relate to mission tasks, system functions, and system suitability.

<u>Components</u>

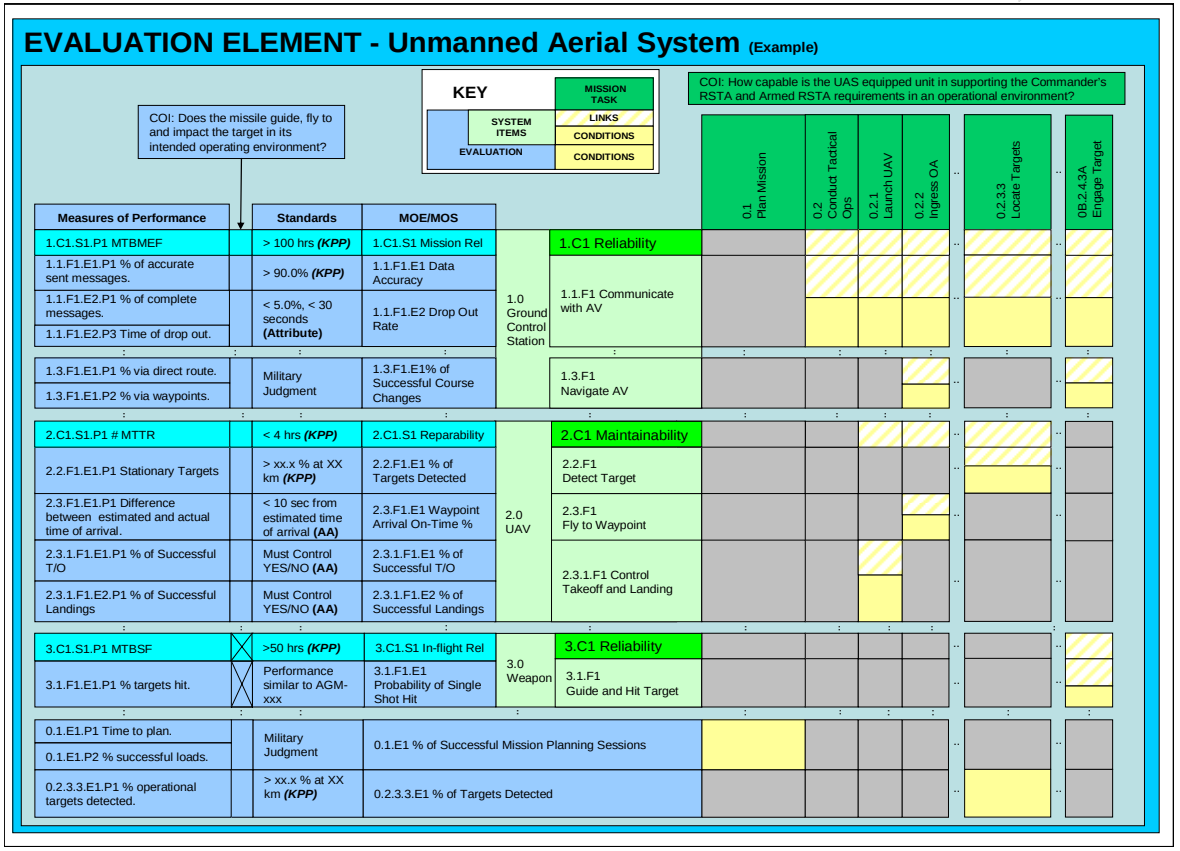
- Conditions: Conditions are assigned to tasks that are linked directly to a MOE in the evaluation element.
- Measure of Effectiveness (MOE): Parameter used to evaluate the system function or mission task.
- Measure of Suitability (MOS): Parameter used to evaluate the suitability of a system.
- Standard: Acceptable performance of the system function or mission task in terms of the MOE or MOS.
- System-focused COI: COI focused on system or sub-system performance. Typically stated, "Does the (system) perform (a specific required capability)?"
- Link to System-focused COI: Column in the evaluation element that identifies which MOE/Ss are used to evaluate the system-focused COI.
- Measure of Performance (MOP): Quantitative or qualitative measure of system performance under specified conditions.

COI: Does the (system) perform (system capability)?					[0.1] Task 1	[0.2.1] 1st Sub-task of Task 2	[0.2.2.1] 1st Sub-task of Task 2.2
1.C1.S1.P1 MOP for MOS 1.C1.S1		Standard for MOS 1.C1.S1	1.C1.S1 MOS for System 1	1.C1 Characteristic of System 1	Input Rule (AND/OR)	Input Rule (AND/OR)	Input Rule (AND/OR)
1.1.F1.E1.P1 MOP for MOE 1.1.F1.E1		Standard for MOE 1.1.F1.E1	1.1.F1.E1 1st MOE for Function 1.1.F1	1.1.F1 Function of Sub-system 1.1	Input Rule (AND/OR)		Input Rule (AND/OR)
					Conditions		Conditions
1.1.F1.E2.P1 MOP for MOE 1.1.F1.E2		Standard for MOE 1.1.F1.E2	1.1.F1.E2 2nd MOE for Function 1.1.F1	1.2.F1 Function of Sub-system 1.2		Input Rule (AND/OR)	
						Conditions	
2.2.C1.S1.P1 MOP for MOS 2.2.C1.S1		Standard for MOS 2.2.C1.S1	2.2.C1.S1 MOS for Sub-system 2.2	2.2.C1 Characteristic of Sub-system 2.2		Input Rule (AND/OR)	Input Rule (AND/OR)
2.2.F1.E1.P1 MOP for MOE 2.2.F1.E1		Standard for MOE 2.2.F1.E1	2.2.F1.E1 MOE for Function 2.2.F1	2.2.F1 Function of Sub-system 2.2		Input Rule (AND/OR)	
						Conditions	
2.2.F2.E1.P1 1st MOP for MOE 2.2.F1.E1		Standard for MOE 2.2.F2.E1	2.2.F2.E1 MOE for Function 2.2.F2	2.2.F2 Function of Sub-system 2.2			Input Rule (AND/OR)
2.2.F2.E1.P2 2nd MOP for MOE 2.2.F1.E1							Conditions
0.2.1.E1.P1 MOP for MOE 0.2.1.E1		Standard for MOE 0.2.1.E1	0.2.1.E1 MOE for Task 0.2.1			Conditions	
0.2.2.1.E1.P1 MOP for MOE 0.2.2.1.E1		Standard for MOE 0.2.2.1.E1	0.2.2.1.E1 MOE for Task 0.2.2.1				Conditions

Element/Interface Development Evaluation Element – Example

Development Keys

- Mission and System Elements.
  - All system functions must have at least one MOE.
  - Mission tasks linked directly to a MOE usually indicate a need for evaluation during OT&E.
- MOEs, MOSs and MOPs.
  - System functions and mission tasks may have more than one MOE.
  - MOEs may have more than one MOP.
  - Both systems and sub-systems may have one or more MOSs.
  - "Dry run" evaluation from MOP to mission task to ensure evaluation is sound.
- Standards.
  - Assign a standard to each MOE to assist in resolution of the MOE. Typically four types of standards:
    - Direct Measurement: Compare demonstrated performance to standard. For example; maximum range.
    - Pass/Fail: Demonstration of a particular feature. For example; required number of hard points.
    - Comparison: Compare performance of two systems. For example; "performance equal to or greater than…"
    - Military Judgment: No specific standard. Military utility will be determined after the evaluation.



Element/Interface Development Test Element

Purpose

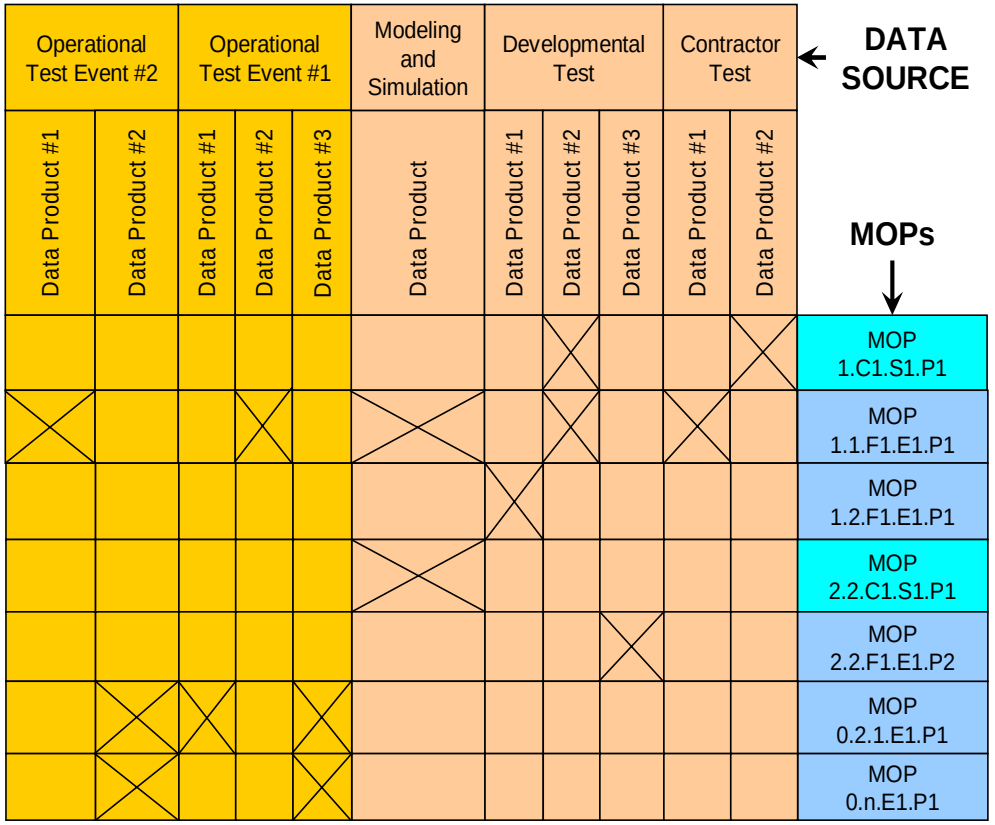
- To describe the data products, the sources of the data products, and how they relate to the evaluation element's MOPs.

Components

- Link to MOPs: Description of which data products support which MOPs.

- Data Products: Specific data packet obtained though a data source satisfying a MOP data requirement.

- Data Sources: The specific source of a data product.



Element/Interface Development Test Element – Example

Development Keys

- Data Products.
  - Data requirements for each MOP are translated into the data products.
  - Requirements should be of sufficient detail to provide the scope of the effort that will generate the data product.
  - Each MOP must have at least one data product.
  - More than one MOP can be supported by a data product.
- Data Sources.
  - Data sources can include: contractor tests, developmental test, operational tests, field exercises, and modeling and simulations.
- Evaluation Strategy.
  - The test element describes an integrated test program.
  - The test element also provides a method to view the acceptability of the entire evaluation strategy.
    - Are the data products sufficient to evaluate the MOE/MOS standard?
    - Which functions/tasks are demonstrated solely in DT?
    - Are there any functions/tasks that are not demonstrated prior to OT? Is this acceptable?

TEST ELEMENT - Unmanned Aerial System (Example)

KEY: TEST ELEMENT | EVALUATION ELEMENT

Initial Operational Test				Limited User Test				DT Missile Shots				DT Flight Tests				Simulation		Contractor Tests		System Integration Lab Test	Measures of Performance	Standards	MOE/MOS
GCS Video	Crew Log	AV Telemetry	Crew Questionnaires	GCS Video	Crew Log	Crew Questionnaires		AV Telemetry	Missile TM	Target TM	Target Damage Reports	AV Telemetry	GCS Video	Airstrip Video	Crew Log	Message Traffic Reports	AV Simulation	Missile Simulation	Link Status Reports	Airstrip Video	Message Traffic Reports	Message Traffic Reports			
																X					X	X	1.C1.S1.P1 MTBMEF	> 100 hrs ***(KPP)***	1.C1.S1 Mission Rel
																X					X	X	1.1.F1.E1.P1 % of accurate sent messages.	> 90.0% ***(KPP)***	1.1.F1.E1 Data Accuracy
																X			X		X	X	1.1.F1.E2.P1 % of complete messages.	< 5.0%, < 30 seconds **(Attribute)**	1.1.F1.E2 Drop Out Rate
																X					X	X	1.1.F1.E2.P3 Time of drop out.		
												X	X	X									1.3.F1.E1.P1 % via direct route.	Military Judgment	1.3.F1.E1% of Successful Course Changes
												X	X	X									1.3.F1.E1.P2 % via waypoints.		
X		X		X								X	X	X			X						2.C1.S1.P1 MTTR	>100 hrs ***(KPP)***	2.C1.S1 Reparability
X		X		X								X	X	X			X						2.2.F1.E1.P1 Stationary Targets	> xx.x % at XX km ***(KPP)***	2.2.F1.E1 % of Targets Detected
X		X		X								X	X	X			X						2.3.F1.E1.P1 Difference between estimated and actual time of arrival.	< 10 sec from estimated time of arrival **(AA)**	2.3.F1.E1 Waypoint Arrival On-Time %
X		X		X								X	X	X			X			X			2.3.1.F1.E1.P1 % of Successful T/O	Must Control YES/NO **(AA)**	2.3.1.F1.E1 % of Successful T/O
X		X		X								X	X	X			X			X			2.3.1.F1.E2.P1 % of Successful Landings	Must Control YES/NO **(AA)**	2.3.1.F1.E2 % of Successful Landings
X				X				X	X	X	X						X						3.C1.S1.P1 MTBSF	> 50 hrs ***(KPP)***	3.C1.S1 In-flight Rel
X				X				X	X	X	X						X						3.1.F1.E1.P1 % targets hit.	Performance similar to AGM-xxx	3.1.F1.E1 Probability of Single Shot Hit
			X			X																	0.1.E1.P1 Time to plan.	Military Judgment	0.1.E1 % of Successful Mission Planning Sessions
			X			X																	0.1.E1.P2 % successful loads.		
X			X	X		X																	0.2.3.3.E1.P1 % operational targets detected.	> xx.x % at XX km ***(KPP)***	0.2.3.3.E1 % of Targets Detected

Element/Interface Development Test & Evaluation Plan

- Documents the four elements and the interfaces between them.
- Two main body chapters: mission evaluation and data sources.

MISSION EVALUATION CHAPTER

Mission
Description of the overall mission.
- **Mission Task**
  Description of the mission task.
  System functions input rule.
  Conditions.
  - Measure of Effectiveness
    Description of the MOE.
    Evaluation Design and Procedure.
    Standard.
    - Measure of Performance
      Description of the MOP.
      Method of Analysis.
      - Data Product (s)
        Listing of required data product (s).
- **System**
  - MOS; MOP; Data Product (s).
  - System Function
    - MOE; MOP; Data Product (s).

DATA SOURCES CHAPTER

Data Sources
Summary description of all data sources.
Summary data product schedule for all data sources.
- **Data Source**
  Purpose and description of the data source.
  Scope and schedule of the data source.
  - **Data Products**
    Description of the data product.
    Listing of the MOPs requiring the data product.

Application
Test and Evaluation Elements

- Test Element:
  - Data is collected from the data sources.
  - Data is then authenticated in terms of quantity, quality and applicability.
  - Authentication body (Data Authentication Group) includes representatives from the test events, other data sources, the evaluator and materiel developer.

- Evaluation Element:
  - Data is then organized and analyzed.
  - Each MOE/S is rated as **met** or **not met** based on the standard.
  - The ratings are used to determine system capabilities and limitations and mission abilities and restrictions.

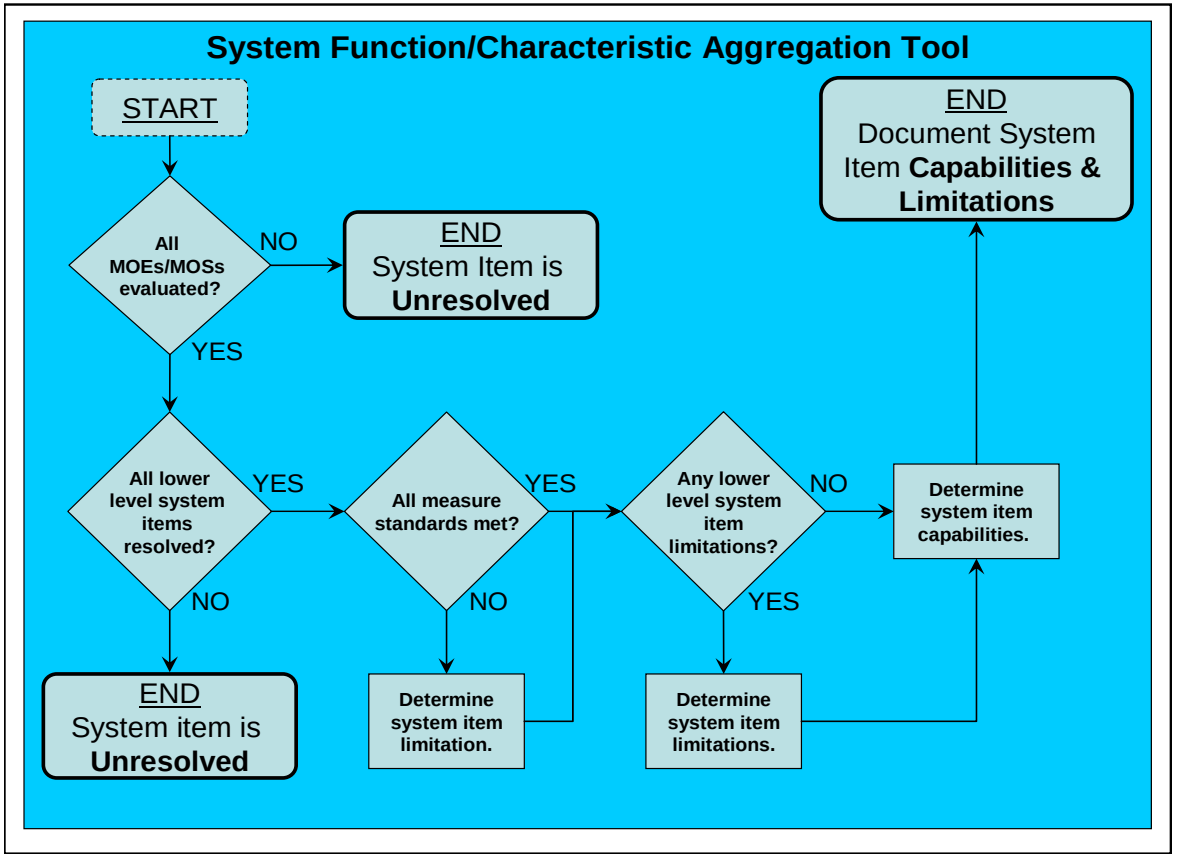
Application
System Element

- System item **capabilities and limitations** are determined at the System Element.
  - Capability: "The (system) has the capability to (function capability with reference to standard)."
  - Limitation: "The (system) is limited to (function capability) which is (shortcoming with reference to the standard)."

- MOE/MOS ratings are applied to the system functions to determine the system capabilities and limitations.

- Capabilities and limitations of lower level system functions are also used to evaluate higher system functions.

- Tool developed to resolve the system functions.



Application
Mission Element

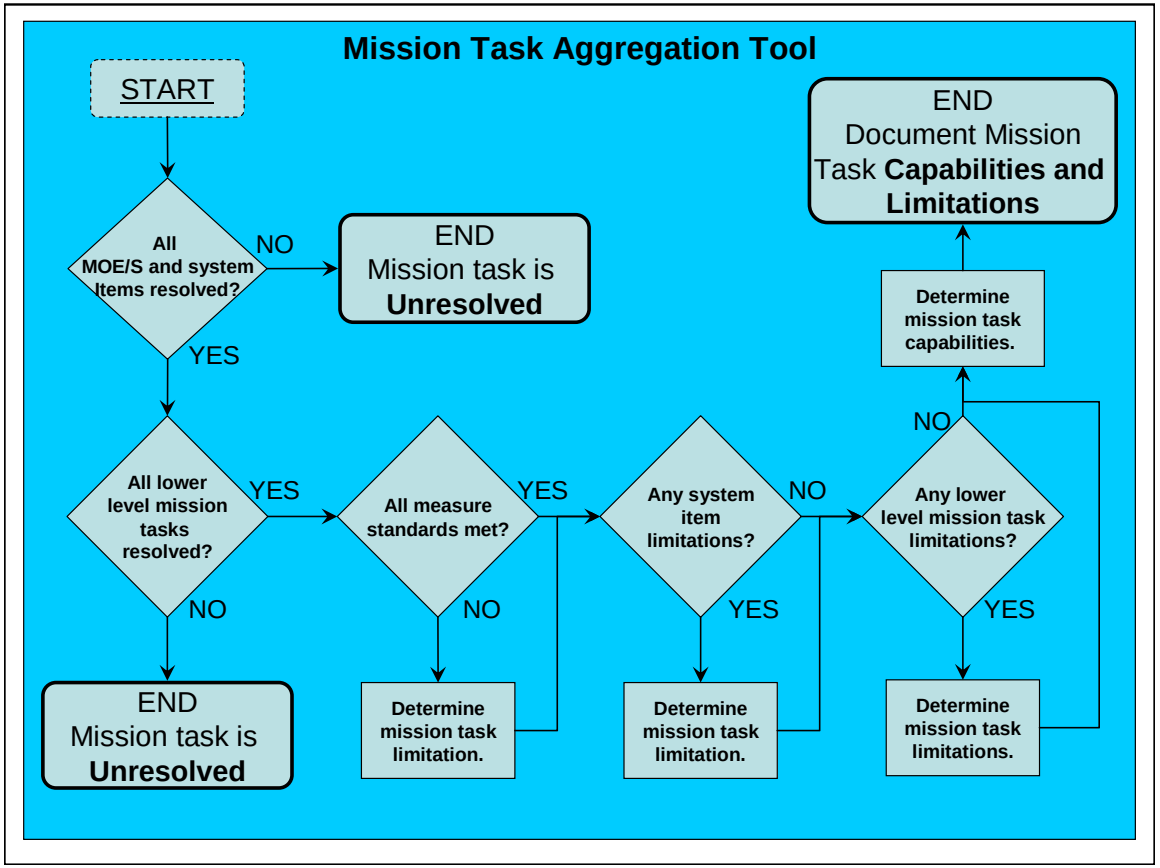
- Mission task **capabilities and limitations** are determined at the Mission Element.
  - Capability: "The (unit) has the capability to (task ability) while (task)."
  - Limitation: "The (unit) is limited to (task ability) while (task) which is (shortcoming to mission task requirement if available)."

- MOE/MOS ratings are applied to the mission tasks to determine the mission capabilities and limitations.

- System item capabilities and limitations are used to determine mission capabilities and limitations.

- Capabilities and limitations of lower level mission tasks are also used to evaluate higher mission tasks.

- Tool developed to resolve the mission tasks.



Application Evaluation Report

- The evaluation report provides the documented results of the evaluation.
  - Mission Evaluation Results.
    - Mission performance in terms of mission threads.
    - Overall mission capabilities and limitations.
    - Individual mission task capabilities and limitations.
  - System Evaluation Results.
    - System performance in terms of attributes and KPPs.
    - System effectiveness and suitability.
    - Overall system capabilities and limitations.

Provides the decision maker with…

a clear picture of the system capabilities and limitations allowing acquisition decisions based on the military utility gained.

Provides the warfighter with…

a clear picture of the unit's capabilities and limitations within the context of the mission.

Strengths

- Provides a mission-based form of evaluation.
  - Military utility of the system immediately apparent to the user.
  - System suitability directly linked to mission capability.
- Outlines a fully integrated test and evaluation program.
  - Promotes synergistic use of data gathered from all sources: contractor test, developmental test, operational test, and modeling and simulation.
  - Promotes early identification of T&E strategy risks.
- Provides continuous evaluation of the mission throughout all system development phases.
  - Impact of development risks on the mission visible in early development.
  - Monitors progress of system development and demonstration within the context of mission capabilities provided.
  - Incremental development strategies are supported by evaluating each increment's capabilities in the context of the overall mission.

Concept Development

Path Forward

- Joint Cargo Aircraft Case Study: Program Currently in T&E Planning.
  - GOAL: Produce an executable System Evaluation Plan.
  - GOAL: Further develop the end-product (completed mission-based evaluation).
- Case Study: TBD Program Currently in T&E Concept Stage.
  - GOAL: Demonstrate a Fully Integrated T&E Concept from MS B to Full-rate Production Decision.
- Tool Development: Develop tools to support development of elements and interfaces and execution of the T&E.

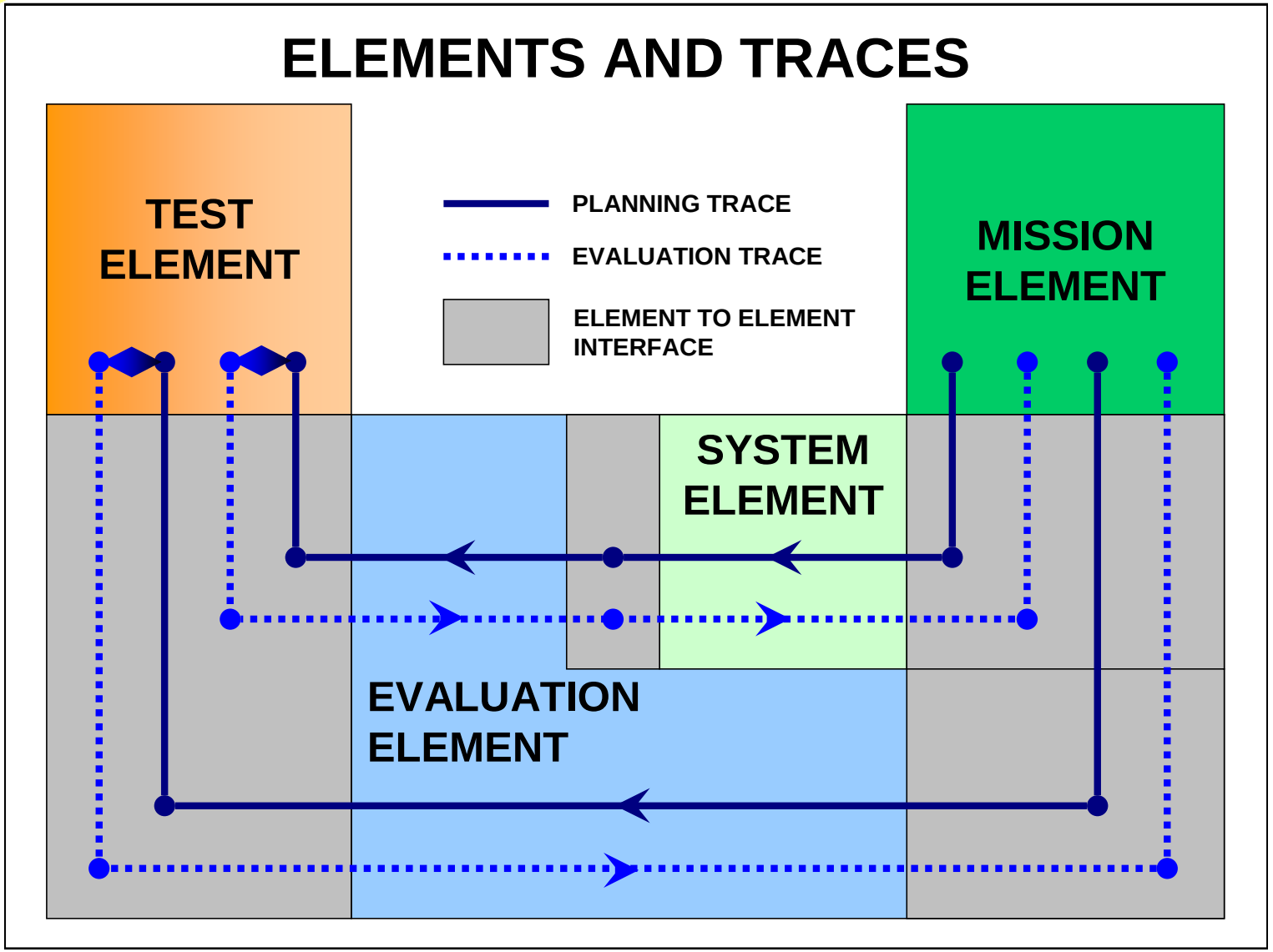
CH-47F Case Study – Results & Lessons Learned

- All four elements and the interfaces successfully developed in a spreadsheet.
- Verified that the concept can be applied to build a mission-based T&E strategy.
- Some system functions/characteristics may require more than one sub-system to execute.
  - Define an "integrated system/sub-system" level in system element to support these functions/characteristics.
- Information Exchange Requirements/Net Ready not defined at the system level.
  - Two options:
    - Define which system or sub-system provides the interoperability capability and link the evaluation requirement to that system's function or characteristic;
    - or link the evaluation requirement to the function or characteristic of an integrated system.
- Need more applicable standards.
  - By Observation: No defined standard. Capabilities and limitations reported as observed.
  - Descriptive: No defined standard. Data taken to support determination of capabilities/limitations.
  - Defined Standard: Standard given IAW military specification, regulation, etc.

Summary

- Mission-based evaluation process has been developed to support T&E planning and execution. Process is comprised of:
  - Four elements.
    - Mission Element ——— Mission Tasks and Sub-tasks.
    - System Element ——— System Items and Functions.
    - Evaluation Element —— Evaluation MOEs and MOPs.
    - Test Element ———— Data Sources and Products.
  - Interfaces.
    - Links between each element have been developed to facilitate T&E planning and execution.
- Execution of the T&E effort provides:
  - the decision maker with a clear picture of the system capabilities and limitations allowing acquisition decisions based on the military utility gained.
  - the warfighter with a clear picture of the unit's capabilities and limitations within the context of the mission.

Element, Links & Traces



Acronym Chart

AA	Additional Attribute
AV	All View (slide 4)
AV	Air Vehicle (slides 11, 13, and15)
CDD	Capabilities Development Document
COI	Critical Operational Issue
CPD	Capabilities Production Document
DAG	Data Authentication Group
DoD	Department of Defense
DT	Developmental Test
GCS	Ground Control Station
JCIDS	Joint Capabilities Integration and Development System
KPP	Key Performance Parameter
MER	Mission Evaluation Report
METT-TC	Mission, Enemy, Terrain, Troops, Time and Civil
MOE	Measure of Effectiveness
MOP	Measure of Performance
MOS	Measure of Suitability
OA	Operational Area
OT	Operational Test
OT&E	Operational Test and Evaluation
OV	Operational View
RSTA	Reconnaissance, Surveillance & Target Acquisition
RT	Remote Terminal
SATCOM	Satellite Communications
SV	Systems View
T&E	Test and Evaluation
T/O	Takeoff
TM	Telemetry
TV	Technical View
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle

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